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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal.

Lancaster, Pa.

Garrison, N. Y.

Annual Subscription, \$6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

THE COMMON GROUND OF THE CHEMIST AND BIOLOGIST¹

THE highest type of mind is forever following backward searching for the simple units from which the universe has been built, formulating laws and running forward in thought on the basis of these laws toward the ultimate. The chemist began with the four elements of Empedocles and Aristotle—air, fire, earth and water; then through the long history of the atoms to Dalton's law and Mendelejeff's table; on to ions, electrons and quantum. The biologist began centuries later with the recognition of the cell in the work of Schleiden and Schwann and has progressed from protoplasm to nucleus, to chromosomes, to electrolytes—and here meets the chemist in his search.

For the chemist, however, the *atom* is still the stable unit, just as for the biologist the *cell* is the stable unit. In spite of all the division and subdivision these two working units become only the more veritable, the atom in chemical reactions, the cell in life or living chemistry: each student moves backwards and forwards from these in his analysis and in his synthesis. The common ground then is—how do the atoms of our elements enter into the life of our cells?

We are continuously faced in cell analysis with the fact that all we find in our cells are the same elements that we find in nature outside of these cells. As Paul wrote in his I Corinthians (chap. 15, verse 47) "The first man is of the earth, earthy: the second man is the Lord from heaven." There is only the factor of life to separate the two.

The two sciences, chemistry and biology, have grown so rapidly in the last fifty years that one can scarcely find a master of both. This is true of knowledge in general. It far outstrips the individual mind. As Pope put it even two centuries ago:

One science only will one genius fit,
So vast is Art; so narrow human Wit.

The biologist has two great fields to study: first, the unicellular organisms which can be obtained in pure culture in which each cell is a duplicate of all other cells in the mass of culture; and, second, those carefully balanced congregations of cells of many varieties living in communities and constituting animals and plants.

In our disease problems the unicellular organisms often inhabit and live in symbiosis, or with destruc-

¹ From the Hygienic Laboratory, Washington, D. C.

tive parasitism, in certain cells of animals or plants. Tuberculosis is a disease of this type. The tubercle bacillus, a race of several strains, may live in its early life in the animal simply as a symbiote or again as a very destructive parasite within the monocyte, one variety of the cells of that animal. The latter is an ameboid cell known to have several chemical functions of its own in the body.

Thanks to the work of Koch and later to the work of Frouin and others we are able to separate and grow almost any strain of tubercle bacillus on synthetic media, and, based on these two methods, we have the essentials for the chemist—pure controllable substances with which to work.

The whole living bacillus growing in the animal is followed by a series of changes known as cell multiplication, cloudy swelling, caseation and softening. So far as our observation is concerned these changes are morphological, but surely ultimately chemical. The dead whole bacillus also will produce the same changes. It is, therefore, reasonable to suppose that some fraction of the dead bacillus has the same property as the living bacillus and that this fraction can be separated from the dead organism. More than that, such fractions once obtained can be systematically studied for their biological action in the normal and tuberculous animal, for their composition and possible synthesis, and finally for their chemical antagonists.

After years of work the U. S. Public Health Service and the National Tuberculosis Association have developed a plan for definite, systematic study of tuberculosis on this basis. For, as Schiller said, "the head must plan with care and thought before the hand can execute." The work outlined in this plan of careful research, however, can not possibly be done by one man.

You will appreciate that for the animal body or the plant body some of the most active biological principles are present in minute amounts. Yet how powerful is the influence of these principles on the whole intact body of minimal quantity after isolation in relative purity! In the animal body the smallest glands often prepare the most powerful units: for example, adrenalin, pituitrin or insulin. The same is apparently true of the bacteria. The most active substances in them are present only in traces. Therefore, it is necessary to grow these bacteria in enormous quantities for each chemical partition to secure enough of one fraction for biological study. To obtain a sufficiently large quantity of bacteria, a special equipment is required. This is found only in the plants of the manufacturing pharmacist who builds his plant for large production. For careful analytical

work the production there, however, must be done under the strictest supervision of the chemist who is chosen to make the analysis. To begin with the glassware and chemicals for the medium, including the water for solution, must remain constants throughout the whole procedure and the only variant should be the strain or race of bacillus used.

After these requirements have been fulfilled and a single strain of the organism chosen and planted on the chosen medium there follows the period of growth at a constant temperature and moisture. With an organism such as the tubercle bacillus, which requires four to six weeks for maturity, the whole quantity is harvested. The bacteria then are separated from the medium and the two resulting fractions, bacteria and media, pass on their way to chemists skilled in special technique for analysis. The procedure for each fraction often requires special methods of separation: for example, in the search for easily oxidized chemical groups the whole process must be followed in an atmosphere of carbon dioxide or nitrogen.

The specialized chemist having supervised the harvesting begins his peculiar analysis. After he isolates the fraction which especially concerns him at the moment he passes it through the committee² to the biologist specially concerned with its reaction in the normal and tuberculous animal.

It is superfluous to-day to emphasize the differentiation that has come in this field of technique and method. Among the biologists we have many specialists as we have among the chemists. We have those who study the influence of a special chemical unit in the normal animal body; those who follow it in the pathological body; those who study its effect on the cells, and those who are skilled in its influence on the body fluids. We have those who dig deeper and follow its influence in the almost fathomless depths of oxidation and reduction both *in vivo* and *in vitro*. For this reason in the isolation of a new chemical unit a sufficient amount must be isolated to retain a sample for later comparisons and to distribute the necessary quantities for each special biological study.

The result of the biologists' work is the guide to the chemists in further purification and fractionation; for, where a specific biological fraction remains intact there will the chemist follow further in his partition.

It will be seen from this brief outline that the great essential is the definition of the problem. The whole problem must be analyzed into its various phases and each phase placed in the hands of the

² Committee on Medical Research, National Tuberculosis Association; see SCIENCE, 64: 265, 1926; Tr. Nat. Tuberc. Assoc., p. 74, 1926.

student best fitted for its study and possible clarification. Each step in the process must be recorded with the same patient care that the good researcher follows in recording the methods and observations of his work. This necessary record involves with so large a program a machinery of its own, for, on the foundation of the records, is built both the ability to reproduce and to correlate the results. The task of synthesizing the knowledge gained is a very difficult one, for men's thoughts are much harder to unite than simple chemical units. To accomplish this, however, we have adopted a system of juries—each jury being carefully chosen for its ability for criticism and constructive suggestion. Before a chosen jury the researchers discuss their work and the committee and student are often safely guided by the uniform advice of such a group of critics.

It must be borne in mind, however, that to secure the best minds for such a duty the problem must be of such importance in human welfare that all are willing to help.

The final synthesis of the knowledge gained will be perhaps more difficult, but it is hoped that it will enable us to control this sickness in a much more effective way than we are able to do at the present time.

Up to to-day in the tuberculosis work there have been isolated some nine or ten fractions from the human tubercle bacillus which have definite physiological action. I will mention only two in illustration—a protein and a phosphatide fraction.

The *protein fraction* belongs to square R of the Johnson plan for analysis.³ The whole living bacilli separated by filtration from the synthetic medium on which they were grown at constant temperature were washed, dried at 37° C., ground in a ball mill and plasmolyzed with ether. The residue, insoluble in ether, was desiccated in vacuum at the same temperature and extracted with cold water. This extract was clarified by the supercentrifuge and filtered through a Berkefeld filter of known porosity. These steps follow the processes A, B, C, E, G, R and S in Johnson's chart. The cold water extract contains the albumin globulins, nucleic acids and non-protein amino acids and some unknown substances. It is found, however, to possess all the properties of crude tuberculin in the proportion of ten milligrams to one cubic centimeter of the Bureau of Animal Industry crude tuberculin.

Crude tuberculin has not changed in the last twenty-five years. It is a dirty compound of many substances concentrated from a boiled beef broth medium and bacilli and yet it is used as the basis for destroy-

ing millions of dollars worth of cattle annually and for the diagnosis of human tuberculosis. It is effective, but it would be infinitely more effective if purified to the point of knowing the chemical composition of its potent fraction, of having this in the condition of procuring known dilutions and of being able to compare it with the same fraction of other well-known strains of bacilli, such as avian, bovine and lepra.

The newly isolated tuberculin fraction distributed to biologists has been found to have very specific action in the normal and tuberculous animal. It produces typical skin and tissue reactions in the tuberculous animal,⁴ cellular reactions,⁵ individual cell reaction differing in type, whether introduced by the micropipette within the cell or allowed to bathe the environment of the cell,⁶ antigenic properties in studies of serum.⁷ On the basis of these studies further work on isolation and purification is clearly indicated.

In this relation it is significant to record that the sulphur mechanism of the human tubercle bacillus is peculiar. This knowledge is in large measure due to the refined technique of the secretary of this division, Dr. Sullivan. Dr. Sullivan, Dr. Smith and the author, working in the Hygienic Laboratory,⁸ have shown that the sulphur complex in H37, the type of culture used in this preliminary work, has apparently a peculiar sulphur mechanism. For both the chemist and the biologist to-day the operating mechanism of such elements as sulphur, phosphorus, boron, silicon, iron, hold apparently the key to many of our difficult problems of oxidation and reduction in living chemistry.

Perhaps more significant even than the protein fractions are the *fatty acid* series. Anderson,⁹ using the same base line organism, H37, by a process described in his paper in a constant atmosphere of carbon dioxide, isolated certain *phosphatide* fractions. These, under the study of Sabin and Doan⁵ and Reznikoff and Chambers,¹⁰ have so far been found to possess characteristics peculiar to them. Especially is this true of the stimulating action possessed by the phosphatide fractions for the rapid multiplication of the special cell of the body which responds to infec-

⁴ Smith, Maurice I., unpublished; Long, Esmond R., unpublished.

⁵ Sabin and Doan, *J. Experimental Medicine*, 46: 645, 1927.

⁶ Chambers and Reznikoff (in press).

⁷ Pinner, Max, *Public Health Reports, Bulletin No. 57*, p. 20, 1926.

⁸ White, Smith and Sullivan, *American Review of Tuberculosis*, 13: 77, 1926.

⁹ Anderson, R. J., *J. Biological Chemistry*, 74: 537, 1927.

¹⁰ Chambers and Reznikoff, *Tr. Nat. Tuberc. Assoc.* (in press).

³ *Am. Rev. Tuberc.*, 14: 169, 1926.

tion with the living tubercle bacillus. The *phosphatide fraction* introduced into the peritoneum produces a veritable tumor of monocytes, the one variety of mesoblast cells that constitutes the tubercle. This function has later been shown to be possessed, after a finer fractionation, by the *saturated fatty acid* of this phosphatide portion of the tubercle bacillus, H37.

The proportions in which these fractions are obtained are indicated in the several papers referred to, but their significance has a direct bearing on another feature of the same combined study being carried out by Dr. DuBois (not yet published) and his associates at the laboratory of the Russell Sage Foundation of Cornell University Medical School in which it is found that phosphorus is an element of the most vital importance in the whole tubercle process. How far this will lead us in lipin metabolism, carbohydrate metabolism, living cell function and primary life functions no one to-day can predict.

In this program of research there are now cooperating three government divisions, eight universities, four endowed laboratories, two manufacturing chemical plants, seven volunteer health bodies and two semi-governmental bodies.

Scientific research has always gained and suffered from the belief that isolation and untrammelled labor is the birthright of its devotees. This came from a day when fear and accusations of witchcraft followed the pursuit of knowledge and from a time when the well-equipped brain was rare. To-day conditions are vastly different. Our equipment of real students is very large, but in the United States our physical equipment of laboratories and apparatus is far greater than our capacity to use them well. Then there is now a sort of hysterical worship of research, and much passes for research that is only mimicry. Still, there is no nation with our potential for the purest type of research, if we only realize our opportunity.

For those interested in research in its truest sense I can speak with some experience. I have yet to meet one, no matter how abstract his problem, who is not happy to give of his time and his knowledge for the advancement of human welfare if he can see the direct application of his special knowledge in the solution of a problem of general welfare and importance to mankind. Not only that, he is also the most honest member of society in his cooperation and seldom loses sight of his high purpose in his selfish desires. They all seem imbued with the thought of Lord Kelvin, who said "There can not be a greater mistake than looking superciliously upon practical applications of science. The life and soul of science is its practical application."

Therefore, I wish to state again that the carefully defined *problem* is the essential thing, and its analysis and apportionment to the proper student is the road to success. There is little need for new institutes of research with their need of robbing other institutes to man them. It is better to apportion the task to a man where he is and to strengthen him in the environment of his growth. Problems must be viewed in their relation to the nation and to the welfare of man and the more widespread our centers of study the more powerful our reserves, for there are always the oncoming students from which we must draw our future strength.

From the example I have given you of research in tuberculosis you will appreciate that the method of systematic study of pure bacteria on synthetic media, with chemist and biologist working in conjunction, is applicable to many of our disease conditions in plant and animal; but far wider is its application to problems of nutrition and bacterial processes in industry and to the problems of life itself. From a study of the simple units of life we shall probably grow into a knowledge of the congregate groups of life undreamed-of before. This is the more likely since there is no living plant or animal that exists free from myriads of these unicellular organisms performing probably the most necessary functions for existence.

Finally, the greatest difficulty comes, as I have noted above, in the correlation and final synthesis of the knowledge gained. One always has to remember the remark of Jean Jacques Rousseau, "I know only that truth is in the things and not in the mind which judges them; and that the less I put my mind in my judgments about them the more sure am I to come near the truth," and so careful record, rechecks by repetition of the things we record, are necessary before we commence synthesis, lest mixing an impure observation we pollute our conclusion. Time alone can tell the success that will follow our efforts, but already the results have abundantly justified the method. Our endeavor should always be

To search through all
And reach the law within the law.

—Tennyson.

WILLIAM CHARLES WHITE
U. S. PUBLIC HEALTH SERVICE

THE MECHANICS OF MATERIALS—A CONTRIBUTION FROM APPLIED SCIENCE TO PURE SCIENCE

DURING recent years we engineers have been frequently reminded of our debt to "pure" science and

of the necessity of the development of pure science if applied science is to continue its progress. These reminders have doubtless been good for us and we have come to realize (what we have always admitted) that the workers in applied science must keep in touch with the developments in pure science, because the advanced theory of to-day may be written into the handbook of to-morrow as an accepted working formula.

In this salutary mental attitude of recognizing our dependence on pure science let us not forget that while pure science furnishes us with generalizations of observed phenomena into concise, summarized statements which we call laws and also gives us root ideas for many of the practical appliances and processes of applied science, yet it is equally true that the study of practical problems has been the source of not a few of the root ideas of pure science.

This is true to a very striking degree for the science which deals with the strength and elasticity of solids—the mechanics of materials. The writer wishes to point out some of the contributions from applied science to pure science in this particular field and to comment on them briefly.

Our sculptors and our architects look back to the days of ancient Greece as the golden age of art and of architecture. In those days, they say, men thought great thoughts, dreamed great dreams, and crystallized their thoughts and dreams into marble and stone. The applied scientist looking back at the same age sees much to admire and recognizes several intellectual giants in his field, with the rugged features of Archimedes towering above all the others, but the applied scientist sees also how in those days the development of scientific thought and especially the development of scientific technique was limited and hindered by a spirit of intellectual aloofness which caused the man of thought to look down on the world of tools and labor.

We find this spirit playing no small part in shaping the life and writings of Archimedes, whom we hail as the father of all engineers—a title which probably makes his ghost highly indignant. This influence is discussed by Plutarch in his comments on Archimedes in the life of Marcellus. The following paragraphs, from Bernard Perrin's translation, are significant:

For the art of mechanics, now so celebrated and admired, was first originated by Eudoxus and Archytas, who embellished geometry with its subtleties, and gave to problems incapable of proof by word and diagram a support derived from mechanical illustrations that were patent to the senses. . . . But Plato was incensed at this and inveighed against them as corrupters and destroyers of the pure excellence of geometry, which thus

turned her back upon the incorporeal things of abstract thought and sense, making use, moreover, of objects which required much mean and manual labor. For this reason mechanics was made entirely distinct from geometry, and being for a long time ignored by philosophers, came to be regarded as one of the military arts. . . .

The phrase "mean and manual labor" is significant; it will be used frequently in this paper. Quoting again from Plutarch:

And yet Archimedes possessed such a lofty spirit, so profound a soul, and such a wealth of scientific theory, that although his inventions had won for him a name and fame for superhuman sagacity, he would not consent to leave behind him any treatise on this subject, but, regarding the work of an engineer and every art that ministers to the needs of life as ignoble and vulgar, he devoted his earnest efforts only to those studies the subtlety and charm of which are not affected by the claims of necessity. These studies, he thought, are not to be compared with any others. . . . And although he made many excellent discoveries, he is said to have asked his kinsmen and friends to place over the grave where he should be buried a cylinder enclosing a sphere, with an inscription giving the proportion by which the containing solid exceeds the contained.

Filled with this spirit of intellectual aloofness the Greek architects designed and built beautiful buildings, but left questions of strength to artisans. Hence there was an almost complete lack of planned control of material, of written rules for sizes of beams and columns, and no designs involving long spans. To learn how to design long-span structures it is necessary for the designer to be willing to perform experiments involving "mean and manual labor" and to give his thought to the phenomena of those experiments, and this sort of thinking simply was not done by the intellectuals of ancient Greece.

An interesting example of the results of this attitude is found in the structural details of a Greek naval storehouse at Piraeus, the port of Athens. A lengthy inscription giving somewhat minutely the dimensions of some of the principal beams in this structure has been studied recently by the Danish architect Marstrand. He finds that some one, possibly the architect Philon, seems to have used proportions and dimensions for beams which agree rather closely with the results of calculations using present-day formulas. However, either such rules were deemed too trivial for the dignity of permanent record, as Plato's attitude would suggest, or they were regarded as "mysteries" trade secrets to be jealously guarded from common knowledge.

In any event the intellectual aloofness of the leaders of Greek thought seems to have been effective in checking the development of any body of knowledge

concerning the strength of the materials of construction. The philosopher and the artist owe an immense debt to ancient Greece; the structural engineer and the machine designer owe but little. Intellectual aloofness does not give birth to that kind of knowledge which renders possible the building of great bridges and of powerful machines.

For the beginnings of anything which can be called a science of mechanics of materials we must pass over a millennium and three quarters from the time of the Greeks to the time of Galilei, who seems to hold the best claim to be regarded as the founder of this science. The development of mechanics of materials from Galilei to Saint Venant may be regarded practically as the development of a body of knowledge concerning the strength and stiffness of bodies under bending action—beams and long columns.

Galilei attacked the problem of the beam, and in doing so showed none of the intellectual aloofness of the Greek thinkers. In introducing his discussion, which is written in the form of a three-part conversation, he starts not with philosophical speculations, nor with formally stated postulates, but with a comment on the methods used in launching ships in the shipyards of Venice. He observed there that large ships require more complete support on the launching ways than do small ships. This indicates to his mind that the very natural method of designing large beams by making them geometrically similar to successful small beams may be neither correct nor safe. He then discusses internal forces holding beams together, and reasons quite in the manner of the modern text-book writer except that he has no concept of the elastic deformation of the material in the beam and assumes it inextensible and incompressible until the beam breaks. He recurs several times to observed structural happenings in ships and building parts. Apparently his attack on this problem gets its inspiration and many of its suggestions as to methods from the "mean and manual labor" of the shipyard and the marble cutting shed.

Galilei's solution of the beam problem leaves out the vital idea of elastic deformation, but we still honor his pioneer attempt to bring a problem of daily life under the rule of mathematical treatment. He stands out as a great pioneer advocate of experimental study. He calls nothing common or unclean which can aid him in his thinking, and finds many a scientific idea in the works of the artisan.

A striking example of the development of a general law of the science of mechanics of materials from a practical problem is furnished by the development of the law of elastic strain—the law of which Galilei had no inkling—Hooke's law, "As the stretch, so the force."

Robert Hooke was very unlike a Greek philosopher. He was small and ugly of figure, and apparently crabbed of temper. The law which bears his name was a by-product of an invention—a clock which could be used on shipboard and which could be used for determining longitude at sea. The ordinary pendulum clock was not feasible for use on a swaying, pitching deck, and Hooke was led to consider the substitution of a spring balance pendulum. In his invention he was successful technically but unsuccessful financially—a fact which added greatly to his sourness of disposition. He made a few watches of a good degree of accuracy, but his financial plans were deadlocked over details of contract.

But as a by-product of his study of the spring balance pendulum he found it necessary to study the deflection of springs during loading and unloading. His study was experimental, and was extended to helical springs and long wires, and, on what to-day would be regarded as wholly inadequate data, he formulated a broad general law for all "springy bodies." Failing in his attempt to get a patent he kept this law to himself as a trade secret for a decade or more. In 1676 he "announced" this law, and several others, in the form of anagrams—each anagram a pi of the letters making up the words of the law. In 1678 in his lecture "De Potentia Restitutiva" he announced the law plainly.

All our present-day mechanics of materials takes Hooke's law as a fundamental postulate. It was based on a comparatively few rather crude experiments; it was stated in a generalized form far more sweeping than was justified by the range of experiment; it has been found to be only a crude approximation for some materials, and is, probably, to be regarded as an approximation for all materials, though a very close one for most rolled metals; it has well-defined limits for every material, a fact which was not recognized at all by its author; but it is simple, and it *works* very fairly well. The mathematical elastician has accepted it uncritically and has used it as the foundation for a complex superstructure of formula, but the law came, not from philosophical thought, but from the practical experience of an ingenious inventor, for Hooke has been characterized as the "first mechanician of his age." He was not at all intellectually aloof from "mean and manual labor," and his law is a shining example of a contribution made by applied science to the basic law of a pure science.

The 156 years which intervened between the announcement of Hooke's law and the development of the skeleton of the present-day elastic theory saw an interesting succession of workers in the field. Some of them—Euler, Bernoulli, LaGrange, Coulomb, for

example—may well be classified as “pure” scientists—men who were fascinated by the problem of a systematic formulation of the laws of elastic action; while others, such as Girard, Tredgold and Barlow, were distinctly “applied” scientists, men who were seeking some systematic rules for designing structural and machine parts. In this period we find Hooke’s law challenged by one investigator, but generally accepted; we see many of the concepts and mathematical methods of the elaborate theory of elasticity brought to light, with much vigorous discussion and with many errors. Then were developed the concept of the neutral axis of a beam, the correlation of Hooke’s law with the stresses and strains in a beam, and a concept of that most elusive property of a material, the elastic limit. At the end of this period of development we find an engineer straightening out the work of a century and a half into a logical though rather complicated systematized body of knowledge.

Louis Marie Henri Navier was born in Dijon, France, about the time of the close of the American Revolution. He was the son of a distinguished lawyer, but lost his parents at the age of four. He was brought up by his uncle, the well-known civil engineer, Gauthey. Young Navier followed his uncle’s calling and studied at the French National School of Bridges and Roads, and in 1808 entered on his career as an engineer.

Navier became a noted bridge engineer, and his memoir on suspension bridges opened to him the doors of the French Academy of Sciences. He was appointed a member of a commission who visited England to study railways there. He was no cloistered theorist, but was in constant touch with the large engineering projects of his day.

While engaged in this engineering work he wrote several memoirs on elastic action of plates and beams, and in these memoirs put the theory of beam action into the general form it has retained ever since, although the memoirs contain much matter which has since been dropped from the beam problem as superfluous. In 1924 we should have held a centennial of the year when Navier “put the beam theory on the map,” for certainly the development of this key problem of the mechanics of materials has played a part in the development of the mechanical age of our civilization in no way second to that played by the development of steam power, electricity and metallurgy.

In 1831 Navier was called to the professorship of analytical mechanics at the School of Bridges and Roads, and shortly thereafter he published his “Lessons in Mechanics,” which may well be regarded as the ancestor of both engineering texts in mechanics and of texts on the elaborate theory of elasticity.

So in the formative period of the science of mechanics of materials from the days of Galilei to the days of Navier the main ideas have come fully as frequently from the shop, the shipyard and the bridge site as from the study of the scholar or the laboratory of the pure scientist aloof from the practical needs of his day.

The half century which followed the day of Navier saw his ideas simplified, rearranged and summarized into two lines of treatment: (1) The simple mechanics of stress in common use to-day by structural engineers and machine designers, and (2) an elaborate mathematical theory of elasticity. As might be expected the first line of treatment was developed by engineers for engineers—Weisbach and Rankine are two names which stand out prominently—but, what is somewhat surprising, the name which probably stands highest in the development of the theory of elasticity is that of an engineer—Barre de Saint Venant. Yes, Saint Venant, whose name stands for elaborate mathematical analysis, for “pure” mechanics of materials *par excellence*, was an engineer. Pupil and later successor of Navier, bridge and highway engineer for the city of Paris, and in his later days professor of agricultural engineering in the French Institute of Agronomy at Versailles, Saint Venant was so far from intellectual aloofness to the problems of everyday life that in his great work developing the elaborate theory of elasticity he frankly avowed his purpose of putting that science in a form available for the structural engineer and the machine designer.

The speaker believes that he is not going too far when he claims that in the development of the science of mechanics of materials the influence of the engineer has been the major factor.

So much for the past; how about the present? In the science of mechanics of materials is applied science still an important source of ideas and concepts for the development of the “pure” science? Two present-day problems in that science will serve as illustrations:

A question of primary importance, still undecided, concerns the cause of structural failure in materials. Is such failure due primarily to excessive internal forces—to *stresses*? Is it due to excessive distortion—to *strains*? Is it due to a tendency to excessive internal stored *energy*? Each of these theories has been held to be the cause of failure, and all with the possible exception of the first-named, stress, have advocates to-day.

There is not time to review, even in outline, the experimental study of this problem; suffice it to point out that the names of engineers are outstanding in the literature of this problem. There is Guest, the ad-

vocate of the shear theory, who began his work in this field about the time he was professor of applied mechanics at Worcester Polytechnic Institute; Hancock, professor of applied mechanics at Purdue, who later was at Worcester; Becker, professor of applied mechanics at North Dakota, who as a graduate student at Illinois contributed an interesting study showing the importance both of shear and of strain; Haigh, metallurgist and engineer at the British Royal Naval Academy at Greenwich, who is the outstanding advocate of the energy theory, and Matsumura and Hamabe, of the Engineering Department of the Kyoto Imperial University in Japan, who have done pioneer work in studying the failure of brittle metals.

The speaker ventures the opinion that this fundamental question is to-day receiving fully as much attention in laboratories of applied mechanics as in laboratories of physics.

A second question of vital importance to the science of mechanics of materials has to do with establishing the limits of accuracy and usefulness of the whole theory of elasticity.

The microscope has become one of the recognized tools of the student of mechanics of materials,¹ and it has shown that the fundamental assumptions of homogeneity, continuity and indefinite divisibility of solids are by no means strictly true.

The study of the behavior of materials under repeated stress has emphasized this fact. Under repeated stress little localized areas of high stress—areas around holes, screw threads and grooves for example—are in danger of becoming nuclei for destructive spreading cracks. Such little areas have no appreciable effect on the behavior of a machine part as a whole under a load repeated but a few times. The civil engineer can usually neglect these localized stresses—and usually does so; the mechanical engineer can not safely neglect them.

However, when the effect of holes, grooves, screw threads and the like on the actual strength of parts subjected to repeated stress is studied by means of tests to destruction and is compared with the theoretical "stress-raising" effect as given by the formulas of the theory of elasticity, serious discrepancies are found, and the effect of such "stress raisers" is, in nearly all cases studied, less than the theory of elasticity would lead us to expect.

¹ In this connection it may be noted that what seems to be the first micrograph of steel was made by Reaumur in 1722. Reaumur started his scientific career as a mathematician, but made his microscopic study of the constitution of steel as a part of his work under a commission by the French government to prepare a report on the useful industries of France. He made this isolated pioneer contribution to our knowledge of materials while working as an applied scientist.

Now the development of this study of the effect of localized stress has taken place almost wholly in engineering laboratories—in the laboratories of the British Aircraft Research Panel, in the engineering laboratories of the British National Physical Laboratory, in the Naval Engineering Experiment Station at Annapolis and in the Materials Laboratory of the U. S. Air Service at McCook Field at Dayton, in the metallurgical and engineering laboratories of the Bureau of Standards. We think we have done some work along this line in the engineering experiment station of the University of Illinois.

The writer believes that it may be justly said of the present-day study of the science of mechanics of materials—the science as distinguished from the art—that to-day the greater part of the work is being done by applied scientists in engineering laboratories.

The rôle of prophet is a fascinatingly dangerous one. The writer can not resist the temptation to attempt that rôle and to make a prediction of a division of the science of mechanics of materials which he thinks will assume major importance within the next generation, and also a prediction that engineers will take a prominent part in its development.

Two practical problems are the forerunners of this division of the science. For some years oil well drillers have found their long steel drill rods breaking at places where stress and strain was supposed to be small, and they have been much puzzled thereby.

A few years ago users of steam turbines were much disturbed by failures of the disc wheels of turbines which seemed to be caused by sidewise "fluttering" at certain critical speeds. There used to be a saying that if he hit just the right note a fiddler could "fiddle down a bridge"—and while, so far as the writer knows, no bridge failure has ever been caused in this way, yet it did seem that in these turbine discs there were failures caused by "tuned" vibration.

Now in both the long drill rods and in the turbine discs we face the problem not of *static* balanced stress, but of *kinematic* stress with interference of waves of stress and resulting high stress in unexpected places. Students of acoustics and of earthquake waves have given hints concerning this problem, but the writer is of the opinion that the science of kinematics of stress and of stress waves is one which is at present in about the same stage of development as was the science of static stress before the days of Navier and Saint Venant, and he further believes that engineers working in engineering laboratories will have a large share in its development.

In support of this last claim there may be cited the work of the late Wilfred Campbell on the mechanics of stress in a rotating turbine disc. This work was done in the shops of the General Electric Company

and involved both careful work in the study and much "mean and manual labor" in experimentation. Plato would certainly have been shocked and alarmed at the conditions under which Mr. Campbell carried on his beautiful and delicate studies of rotating and fluttering discs. He solved a special problem in the kinematics of stress and left as his monument what the writer believes will be recognized as an important piece of pioneer work in a new division of the science of the mechanics of materials.

The writer is not one of those who would meet the attitude of "intellectual aloofness" of the old-time classical philosopher with a scorn of "theory" which characterizes a certain type of "practical" man. He believes that both intellectual aloofness and self-satisfied practicality are signs of a narrow mind. There have come to all departments of science contributions from the study, the library and the laboratories of the sciences which are little concerned with the immediate practical results of their experimentation; there have come contributions also from the machine shop, the structural shop and the engineering laboratory.

May we not picture pure science as occupying quarters in an impressive stone building at one end of a busy street, and applied science as occupying quarters in a plain well-lighted shop at the other end. Between the two structures many messengers go back and forth carrying books and papers and driving trucks loaded with machines and apparatus. The highway between pure science and applied science is not a one-way street.

H. F. MOORE

UNIVERSITY OF ILLINOIS

SCIENTIFIC EVENTS

COOPERATIVE ETHNOLOGICAL AND ARCHEOLOGICAL INVESTIGATIONS BETWEEN THE SMITHSONIAN INSTITUTION AND STATE, EDUCATIONAL, AND SCIENTIFIC INSTITUTIONS

At the past session of the Congress, the following act authorizing cooperation in ethnological and archeological investigations was enacted:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Smithsonian Institution is hereby authorized to cooperate with any State, educational institution, or scientific organization in the United States for continuing ethnological researches among the American Indians and the excavation and preservation of archeological remains.

Sec. 2. That there is hereby authorized to be appropriated, out of any money in the treasury not otherwise

appropriated, the sum of \$20,000, which shall be available until expended for the above purposes: *Provided*, That at such time as the Smithsonian Institution is satisfied that any State, educational institution, or scientific organization in any of the United States is prepared to contribute to such investigation and when in its judgment such investigation shall appear meritorious, the Secretary of the Smithsonian Institution may direct that an amount from this sum equal to that contributed by such State, educational institution or scientific organization, not to exceed \$2,000, to be expended from such sum in any one State during any calendar year, be made available for cooperative investigation: *Provided further*, That all such cooperative work and division of the result thereof shall be under the direction of the Secretary of the Smithsonian Institution: *Provided further*, That where lands are involved which are under the jurisdiction of the Bureau of Indian Affairs or the National Park Service, cooperative work thereon shall be under such regulations and conditions as the Secretary of the Interior may provide.

Approved, April 10, 1928. (Public—No. 248—70th Congress.)

The appropriation of \$20,000 authorized by the above act was made in the Deficiency Act, approved May 29, 1928.

1. From the above appropriation, the Secretary of the Smithsonian Institution may approve expenditure of a sum equal to that provided by any state or educational or scientific organization, not exceeding \$2,000 in any one state in any one year, when satisfied that such state or organization is prepared to contribute to such investigation, and when in his judgment cooperation by the Institution in such investigation is justified.

A. Requests for cooperation should be made by the responsible officer of the State, educational institution or scientific organization interested.

B. Applications should be accompanied by full explanatory statements of the work proposed, the location, purpose and any other pertinent details, the name of the field representative, if any, of the applicant, and should state whether any supervisory salaries are to be paid from that portion of the joint fund provided by the applicant, and if so, the amount thereof. It is intended that all funds provided for such cooperative work shall be devoted strictly to the prosecution of definite projects contemplated by the act, and shall not be used for the payment of regular salaries or other regular expenses of any organization.

C. Applicants must present suitable evidence of the availability of funds for cooperative use and will present at regular intervals detailed accounts of expenditures therefrom. Full instructions will be furnished regarding expenditures from allotments by the Institution, which must be made to conform with the accounting regulations of the United States Treasury Department.

D. A report covering each cooperative investigation, including copies of all maps, charts, photographs or other notes relating to the work shall be filed with the Smithsonian Institution by the leader of the joint investigation within a reasonable period following its completion. It is contemplated that a proper report embodying the results obtained will be prepared for publication by the leader or his agent within a reasonable time.

2. The act provides that "all such cooperative work and division of the result thereof shall be under the direction of the Secretary of the Smithsonian Institution." The leader of any joint investigation must be approved or designated by the Secretary, who may at any time, if in his judgment it be desirable, send a representative to the scene of operations to inspect the work, at the expense of the allotment made for the particular investigation concerned.

3. Any cooperative investigation involving lands under the jurisdiction of the Departments of the Interior, or of Agriculture, will be subject to such rules as the secretary of the department having jurisdiction may impose.

C. G. ABBOT,
Secretary

SMITHSONIAN INSTITUTION

PROPAGATION OF THE GIANT TORTOISE IN THE UNITED STATES

THE hunting party sent by the New York Zoological Society to the Galapagos Islands in March returned in May with 180 giant tortoises, all of which are to be devoted to attempts at propagation.

The director of the expedition has already located colonies of 15 to 30 tortoises at Balboa, Canal Zone; San Diego, California; Superior, Arizona; San Antonio and Houston, Texas, and New Orleans, Louisiana. Other breeding stations will be located in southern Florida and probably at other points nearer the tropics.

All the tortoises have been numbered, weighed and measured. These and other scientific records will be made annually until the little known changes due to growth and age are ascertained.

The tortoise colonies already established are under the protection of scientific or other responsible organizations. They have in each case an acre of range, more or less, are behind tight fences and before December will have shelters to which they can retreat during chilly weather or unusual dampness. There have been no losses and all are in thriving condition.

The Galapagos tortoise is now known to be extinct on all islands of the group except Albemarle and Indefatigable, with the possible exception of Duncan Island. All of the tortoises secured were found in the

mountains of southern Albemarle, which involved a week's journey with pack animals.

We confirm the opinions of other observers who have visited the Galapagos during the past 30 years, that the giant tortoise cannot long survive on those islands, where all its eggs and young are destroyed by wild dogs, pigs, cats and rats. Hunting by parties from passing vessels seems to be ended, as tortoises are now to be found only among mountains difficult to reach.

The expedition found in a cave a dozen large and fairly complete skeletons of the long-extinct tortoise of Charles Island. No other scientific work was attempted, except the securing of rooted plants of an absolutely spineless cactus discovered by the director, which is now being propagated at Balboa, C. Z., and at the Desert Arboretum at Superior, Arizona.

The U. S. Bureau of Fisheries cooperated with the Zoological Society to the very important extent of lending a ship, the *Albatross II*.

C. H. TOWNSEND,
In charge of Expedition

FIELD TRIP OF OHIO GEOLOGISTS

THE annual field trip of the geological section of the Ohio Academy of Science was held in the vicinity of Dayton and Springfield, Ohio, on June 1, 2 and 3. Thirty-eight people representing thirteen institutions were in attendance.

J. Ernest Carman, of Ohio State University, and C. F. Moses, of Muskingum College, acted as guides on the first day of the excursion, when the party visited the outcrops of the Devonian in the Bellefontaine outlier. On the second and third days August F. Foerste acted as guide taking the party to outcrops of the Silurian in both the Springfield, Ohio, region and the area near the western boundary of the state.

Saturday evening, at the Engineers' Club of Dayton, the group was addressed by Arthur E. Morgan, president of Antioch College, formerly chief engineer of the Miami Conservancy District, on the problems of flood prevention at Dayton.

A fifteen-page mimeographed pocket field guide was published for the convenience of the members of the party. The booklet contained routes, sections to be visited, and a short account of the general relations of the formations.

The colleges and universities represented on the trip included: Antioch, Bowling Green, Kenyon, Miami, Muskingum, Ohio State, Ohio Wesleyan, Toledo and Wooster.

A. C. SWINNERTON

ANTIOCH COLLEGE,
YELLOW SPRINGS, OHIO

ELECTION OF OFFICERS OF THE NATIONAL RESEARCH COUNCIL

CHANGES among the central officers and the divisional chairmen of the National Research Council have recently been made, by elections, as follows: Chairman of the council, George K. Burgess, director, U. S. Bureau of Standards; third vice-chairman, Simon Flexner, director, Rockefeller Institute for Medical Research; treasurer, Joseph S. Ames, dean of the college faculty, professor of physics and director of the physical laboratory, the Johns Hopkins University; chairman of the division of chemistry and chemical technology, George A. Hulett, professor of physical chemistry, Princeton University; chairman of the division of geology and geography, Arthur Keith, geologist, U. S. Geological Survey; chairman of the division of medical sciences, William Charles White, chairman, medical research committee, National Tuberculosis Association, and pathologist in charge of tuberculosis research, U. S. Hygienic Laboratory; chairman of the division of biology and agriculture, Lorande L. Woodruff, professor of protozoology, Yale University.

Present chairmen of other divisions continue as follows: Division of federal relations, George Otis Smith, director, U. S. Geological Survey; division of foreign relations, R. A. Millikan, director, Norman Bridge Laboratory of Physics, California Institute of Technology; division of states relations, R. A. Pearson, president, University of Maryland; division of educational relations, Vernon Kellogg, permanent secretary, National Research Council; division of physical sciences, Dayton C. Miller, professor of physics, Case School of Applied Science; division of engineering and industrial research, Elmer A. Sperry, chairman, board of directors, Sperry Gyroscope Company, Brooklyn, New York; division of anthropology and psychology, Knight Dunlap, professor of experimental psychology, the Johns Hopkins University.

VERNON KELLOGG,
Permanent Secretary

SCIENTIFIC NOTES AND NEWS

FIVE distinguished American engineers have been elected honorary members of the American Institute of Electrical Engineers. They are Thomas A. Edison, John J. Carty, Michael I. Pupin, Ambrose Swasey and Elihu Thomson. This is the first time that any American honorary members have been elected.

FOR his distinguished service to humanity in the field of mathematical physics, Professor Michael I. Pupin, professor of electromechanics in Columbia University, has been elected the sixth honorary knight for life of the Loyal Knights of the Round Table, an

international luncheon-friendship club, with tables in more than 65 cities in Canada and the United States. The other five "knights for life" have been Luther Burbank, Thomas A. Edison, Charles E. Hughes, Robert Andrew Millikan and Dr. Wilfred T. Grenfell.

DR. EDWARD DEAN ADAMS, New York engineer, who represented the Engineering Foundation at the dedication of the Louvain Library and the engineers' memorial carillon and clock on July 4, has received an honorary doctorate from the University of Louvain and has been made a commander of the Order of the Crown by the Belgian government.

DR. GEORGE FILLMORE SWAIN, professor of civil engineering at Harvard University, was made the recipient of the Benjamin G. Lamme medal for his contribution to the advancement of the art of technical training by the Society for the Promotion of Engineering Education, in session at the University of North Carolina, Chapel Hill. Dr. Swain is the first to receive the medal, which will henceforth be awarded yearly in accordance with provisions in the will of the late Benjamin G. Lamme.

CAPTAIN SIR HUBERT WILKINS has received from the American Geographical Society the Samuel F. B. Morse gold medal for geographical research.

ACCORDING to the *Journal* of the American Medical Association, the California Medical Association at the recent annual meeting awarded its research prize to Drs. Phoebus Berman and William H. Leake, both of Los Angeles, for their paper on "The Effect of Emetine on the Rabbit's Heart—An Electrocardiographic Study," and the clinical prize to Dr. Cyril B. Courville, Loma Linda, for his paper on "Intracranial Neoplasms—The Principle of Transmitted Pressure in the Production of Symptoms."

F. H. ROSENCRANTZ, director of engineering, International Combustion Engineering, Ltd., was awarded the Kelvin gold medal of merit by the British Institution of Electrical Engineers in recognition of his work in the field of combustion.

THE following have been elected foreign members of the Royal Society: Professor Albert Brachet (Brussels); Professor David Hilbert (Göttingen); Professor Paul Langevin (Paris); Professor Richard Friedrich Johannes Pfeiffer (Breslau); Professor Ludwig Prandtl (Göttingen), and Professor Richard Willstätter (Munich).

SIR STCLAIR THOMSON, of London, has been elected a corresponding member of the Société de Laryngologie des Hôpitaux de Paris, of the American Stomatological Association and of the Philadelphia Laryngological Society.

THE diploma of honorary membership of the University of Innsbruck has been conferred on Mrs. Ogilvie Gordon, of London, in recognition of her geological researches on the Dolomites of South Tyrol. Mrs. Gordon has also been nominated as an honorary correspondent by the Geological Survey of Austria.

DR. GEORGE W. CRILE, Cleveland, was awarded the honorary degree of doctor of laws by the University of Glasgow on June 20.

SR. ING. JOAQUIN GALLO, director of the National Astronomical Observatory of Mexico, received the honorary degree of doctor of science at Northwestern University on June 18.

MIDDLEBURY COLLEGE conferred the honorary degree of doctor of science on Ralph C. Bryant, professor of lumbering at Yale University, at the commencement exercises on June 18.

DR. PERCY R. HOWE, director of research in the Forsyth Dental Infirmary and professor of dental science at Harvard University, received the honorary degree of doctor of laws from Bates College, Maine, on June 19.

WILLIAMS COLLEGE has conferred the honorary degree of doctor of science on Professor Walter A. Bratton, head of the department of mathematics at Whitman College.

DR. CHARLES G. ABBOT, secretary of the Smithsonian Institution, has been appointed by President Coolidge to be a member of the National Advisory Committee for Aeronautics.

THE secretary of interior has announced the members of the commission authorized by the Seventieth Congress to make an expert investigation of the Boulder and Black Canyons on the Colorado River in connection with the proposed development of the river. The members of the commission, three engineers and two geologists, are: Major-General William L. Sibert, United States Army, retired; D. W. Mead, engineer, Madison, Wis.; Robert Ridgway, engineer, of New York; Charles P. Berkey, geologist, of New York, and W. J. Mead, geologist, of Madison, Wis.

RAYMOND L. DITMARS, curator of reptiles and mammals of the New York Zoological Society, has been elected president of the Westchester County Conservation Association.

At the last meeting of the Johns Hopkins Medical Society for the year 1927-28, the following officers were elected for the coming year: Dr. William Holland Wilmer, *president*, and Dr. E. M. K. Geiling, *secretary*.

DR. ELLICE McDONALD, chairman of the cancer research fund of the graduate school of medicine in the University of Pennsylvania, has been appointed research oncologist in the Philadelphia General Hospital and to membership on the radiological-clinical staff. A subcommittee in cancer research has been appointed, consisting of Drs. George M. Dorrance, Charles C. Norris and Ellice McDonald, to direct cancer research.

DR. ROBERT B. SOSMAN has resigned from the geophysical laboratory of the Carnegie Institution of Washington, and will be with the newly established research laboratory of the United States Steel Corporation, at the plant of the Federal Shipbuilding and Dry Dock Company, at Kearny, New Jersey, after July 21.

P. V. CARDEN, farm economist, has been appointed director of the Utah Experiment Station, succeeding William Peterson, who will continue as director of extension.

DR. A. A. L. RUTGERS, director of the department of agriculture, industry and commerce of the Netherlands Indies, Buitenzorg, Java, has resigned that position and also that of president of the Fourth Pacific Science Congress, which will be held in Batavia and Bandoeng, Java, May 16 to 25, 1929, in order to accept appointment as Governor of Surinam (Dutch Guiana, South America). Dr. O. de Vries, director of the Rubber Experiment Station at Buitenzorg, has been appointed president of the Fourth Pacific Science Congress in the place of Dr. Rutgers.

IN response to an invitation from the California Academy of Medicine, Dr. George Barger, professor of chemistry as applied to medicine at Edinburgh University, is visiting California. He gave several lectures during the course of his visit.

RECENT visitors to the United States include Dr. Christobal M. Hicken, professor of botany, University of Buenos Aires, Argentina, and Professor Takashi Naito, assistant professor of botany and phytopathology, Imperial College of Agriculture and Forestry, Kagoshima, Japan.

A GROUP of six teachers from the University of California College of Dentistry, including Drs. Edwin H. Mauk and Robert E. Keys, plate dentures; Dr. Henley E. Miller, oral surgery, extraction and anesthesia; Dr. J. Raymond Gill, crown and bridge and porcelain; Dr. J. W. Roush, operative dentistry and periodontia, and Mr. C. O. Tufts, radiography, sailed on May 25 for Wellington, New Zealand, to give a summer course of one week, beginning on June 25, on modern American dental practice before the New Zea-

land Dental Association. All expenses of the expedition were defrayed by the association.

DR. DAVID EUGENE SMITH, professor of mathematics at Columbia University, has returned from Europe, where he has been a visiting Carnegie professor of international relations. Representing the Carnegie Endowment for International Peace, he lectured at University College, London; University of Toulouse, France, and the University of Montpellier, France.

DR. GEORGE E. PFAHLER, vice-dean of radiology in the University of Pennsylvania's graduate school of medicine, has sailed for England, to represent the United States at the international conference on cancer at London from July 16 to 22. Later he will attend the International Congress of Radiology which opens on July 23 in Stockholm. A second representative from the University of Pennsylvania at the London conference will be Dr. William Seifriz, professor of botany and a member of the cancer research fund committee of the graduate school of medicine.

LAURENCE VAIL COLEMAN, director of The American Association of Museums, has left for an extended tour of Latin America, during which he will visit museums and other educational institutions. He will work southward along the east coast of South America to Buenos Aires, across to Santiago, and northward to Panama. The trip has been made possible through the association's committee on Pan-American cooperation and has for its purpose to develop closer relations between all the museums of the new world.

DR. FRANK C. WHITMORE, head of the department of chemistry at Northwestern University, is resuming residence in Evanston following a year's leave of absence from university work. During the past year, he has served as chairman of the division of chemistry and chemical technology of the National Research Council.

DEAN DEXTER S. KIMBALL, of the college of engineering at Cornell University, delivered the principal address at the dedication of the Riggs hall of engineering at Clemson College on June 4.

A STATUE to Lieutenant-Commander George W. De Long was unveiled at Woodlawn Cemetery, New York, on July 4, in the presence of the lost commander's widow and Herbert Wood Leach, of Brockton, Mass., only survivor of the polar expedition of 1879-81 in which De Long lost his life. Captain Sir Hubert Wilkins, Vilhjalmur Stefansson and Anthony Fiala spoke at the unveiling. The statue was the work of Leonard Craske, of Boston.

DR. FRANCIS H. SMITH, professor emeritus of natural philosophy at the University of Virginia, died on July 5 in his ninety-ninth year.

PROFESSOR WILLIAM ESTY, head of the electrical engineering department at Lehigh University, died on July 7, aged sixty years.

PROFESSOR ARTHUR SCHÖNFLIESS, of the University of Frankfurt, the well-known mathematician, died on May 27, at the age of seventy-five years.

PROFESSOR R. LEPETIT, president of the Italian Society of Chemical Industry, known for his work on dyes, died on March 27, aged sixty-two years.

ACCORDING to press dispatches, Assam Dina, owner of the observatory on Mont Blanc, who was building a large observatory on Mont Saleve in France, has died. His widow, the former Mary Wallace Shillito, of Cincinnati, is expected to complete the \$6,250,000 Mont Saleve Observatory, which was intended as a gift to the French nation. The diameter of the telescope is to be 105 inches, five inches larger than that of the telescope on Mt. Wilson, California.

It is announced that the fifty-first annual congress of the French Association for the Advancement of Science will be held at La Rochelle from July 23 to 28.

THE annual conference of the British Museums Association was held at Glasgow, Scotland, from July 2 to 6, inclusive.

THE chairman of the executive committee of the Institute for Research in Tropical America announces that increased facilities are available for naturalists who may wish to study at the Barro Colorado Island Laboratory in the Panama Canal Zone. Persons wishing to proceed to Panama should address the office of Dr. Thomas Barbour, director of the Harvard University Museum, Cambridge, Massachusetts, whence credentials are issued enabling applicants to secure reduced transportation rates, pass on the Panama Railroad, commissary privileges while in the zone, etc.

IN June, 1927, the Department of State transmitted invitations from the executive secretary of the congress to foreign governments to send one or more representatives to that congress. Some governments accepted this invitation, and others declined. On May 1, 1928, the following resolution was approved by the president of the United States: "*Resolved*, By the senate and house of representatives of the United States of America in congress assembled, that the president be, and hereby is, authorized and requested to extend invitations to foreign governments to be represented by delegates at the International Congress

of Entomology to be held in the United States in 1928." In accordance with this resolution the president, through the diplomatic officers of the United States government, again called the attention of foreign governments to the invitations previously extended them, with the statement that in view of the resolution above quoted, the congress has now an official status and that therefore their invitations are extended by the president of the United States.

THE American Society of Orthodontists has made a second grant of \$3,000 to the University of California College of Dentistry for a continuation of the study in the field of orthodontics, begun in October, 1927. The experimental work is being done on monkeys, under Professor John A. Marshall, in the Hooper Foundation for Medical Research and the college of dentistry of the university. The advisory committee includes Professor Karl F. Meyer, director of Hooper Foundation; Dr. Albert E. Ketcham, of Denver; Dr. James D. McCoy, of Los Angeles, and Dr. Allen H. Suggett, of San Francisco.

THE importance of careful investigation prior to introduction of a species of big game is appreciated by the Forest Service and Biological Survey of the United States Department of Agriculture and the State Game Department of Arizona. A proposal having been made to introduce elk from Yellowstone Park in the Chiricahua Mountains of southeastern Arizona, an "elk committee" was formed, and spent several days between June 19 and 23 in studying the problem on the ground. This group was made up of Fred Winn, supervisor, Coronado National Forest, and president, Tucson Natural History Society; Tom Bentley and Carl Scholefield, forest rangers; D. A. Shoemaker, range examiner, district office of the Forest Service, Albuquerque, N. Mex.; Walter L. Hatley, Chiricahua Cattle Growers' Association, Sunglow, Arizona; D. E. Pettis, State Game Warden, Phoenix, Arizona; J. A. Diffin and C. P. Hawkins, president and secretary, respectively, of the Bisbee Game Protective Association, Bisbee, Arizona; Chas. T. Vorhies, entomologist; A. A. Nichol, assistant entomologist, secretary, Tucson Natural History Society, and W. G. McGinnies, grazing range specialist, all from the University of Arizona, Tucson, Arizona, and Walter P. Taylor, biologist, Biological Survey, Tucson, Arizona. The tentative decision of the committee was against introduction of the elk, though the final determination of the point was postponed until January 1, 1929. No evidence was adduced as to former occurrence of the animals in the Chiricahua Mountains. The committee felt that the funds available might better be spent in restocking the range with wild turkeys and mule deer than in bringing in elk. Turkeys are now

extinct in the Chiricahua Mountains, though known to have occurred in former times. Mule deer are still to be found locally, though formerly much more abundant.

THE National Fund for Scientific Research of Belgium has established a special committee to draft the statutes of the fund. Approximately 110,000,000 Belgian francs have been collected up to the present time. The establishment of the fund occurred under the following circumstances: On October 1, 1927, on the occasion of the celebration of the 110th anniversary of the foundation of the Cockerill Works, the King of the Belgians made a speech in which the attention of the nation was drawn to the dangers resulting from the neglect of scientific research. Consequently the Universities of Brussels and Louvain decided to organize a propaganda meeting in the Palais des Académies, on November 26, 1927. This proposal aroused so much public enthusiasm that the state universities of Ghent and Liège immediately associated themselves with the initiative which had been taken. During the course of this important demonstration, when the king once more desired to appeal for the cause of science, the propaganda committee for the National Scientific Research Fund was established, under the chairmanship of M. Emile Francqui, Minister of State, president of the "Fondation universitaire."

MARCH 18 marked the closing of the 1928 season of the Southern Cross Observatory, the unique institution at Miami, Florida, without a building or professional observer. The observatory, which is purely for public use, is situated in a public park of Miami, and embraces six 5-inch refractors, a spectroscope, transparencies and stereopticon facilities. The attendance during one evening in February reached 4,000. Dr. Frederick Slocum, of the Van Vleck Observatory, Wesleyan University, lectured on January 28 to 30 to large audiences on "The Lure of the Eclipse" and "Our Neighbors, the Planets." The observatory has proved interesting to northern visitors of some information because of its far southern latitude. The Southern Cross comes into distinct view, although low on the horizon, while all the first magnitude stars and fifty-eight of the sixty-second magnitude stars appear during the year.

THE American Pharmaceutical Association has selected a site in Washington, in view of the Lincoln Memorial and between the National Academy of Sciences and the Naval Hospital, as the location for its national headquarters. The headquarters building, plans for which soon are to be drawn, is to cost approximately \$500,000 and will house a museum, library, research laboratory and publication

department. Funds to carry out this enterprise were raised by popular subscription among the pharmaceutical interests throughout the United States, Canada, Cuba, Hawaii and Porto Rico.

UNIVERSITY AND EDUCATIONAL NOTES

HARVARD UNIVERSITY and the University of Rochester will share jointly a bequest of \$640,988 from the estate of Dr. Charles A. Dewey, of Rochester.

COLGATE UNIVERSITY and Vassar College are each to receive a half of the residuary estate of Miss Evelyn Colgate, who died last month. The estate probably will amount to \$150,000. Other gifts to Colgate recently announced amount to \$26,000.

FUNDS available from two estates will make possible the early construction of a new chemistry building at Washington and Jefferson College at a cost of more than a quarter of a million dollars.

DR. J. B. REYNOLDS, who has been president of the Ontario Agricultural College since 1920, has resigned. The vacancy has been filled by the appointment of Dr. G. I. Christie, formerly director of the Agricultural Experiment Station at Purdue University, Lafayette, Indiana.

DR. JOSEPH EUGENE ROWE has resigned his position as head of the department of mathematics and director of extension in the College of William and Mary to become president of the Clarkson Memorial Institute of Technology at Potsdam, N. Y.

DR. EDMUND W. SINNOTT, professor of botany and genetics at the Connecticut Agricultural College, has been appointed professor of botany and head of the botanical department at Barnard College, Columbia University, to succeed the late Dr. Herbert Maule Richards.

EMMETT REID DUNN, associate professor of zoology at Smith College, has been appointed professor of zoology at Haverford College.

PROFESSOR HARRY B. WEISER, head of the department of chemistry of Rice Institute, Texas, will give two courses of thirty lectures each in the field of colloid chemistry in the forthcoming summer session at Western Reserve University, beginning June 18.

DR. LOWELL J. REED, professor of vital statistics and biometry, the Johns Hopkins University School of Hygiene and Public Health, will give a course for public health workers at the summer session of the University of California, Berkeley, from July 2 to August 11.

DISCUSSION AND CORRESPONDENCE SYEVERNAYA ZEMLYA (NORTHERN LAND)

PERHAPS it is time now to correct a small mistake of geographical nomenclature, which has appeared in the literature (chiefly newspaper articles) of different countries and threatens to become permanent through repeated use.

The writer refers to the names of the islands discovered in the Arctic Ocean, north of the Taimuir Peninsula, in 1913, by the Russian hydrographic expedition under Captain Vilkitski. They were christened by the expedition: Emperor Nicholas II Land, the name applied to the largest northern island, perhaps a double one; Tsarevich Alexei Island, located about thirty-five miles north of the Taimuir Peninsula; Dr. Starakodonski Island, a small one, located in the strait between two former islands, four miles off the Tsarevich Alexei Island.¹

After the Russian revolution the names of these northern islands were changed by the new Russian Soviet Government, as were the names of many towns, streets, etc. The name Syevernaya Zemlya (Northern Land) has been applied now to the Emperor Nicholas II Land; the name of Maly Taimuir (Little Taimuir) to the Tsarevich Alexei Island. The name of Dr. Starakodonski Island has remained unchanged. These names one finds on the new map of the U. S. S. R., published in 1927 by the Commissariat of the Interior of the present Russian government. Only these names are used in Russian newspapers in articles dealing with different Arctic enterprises and in this or other way touching the islands under consideration. The idea of the name of Lenin Land as a substitute for the former name was also fostered in Russia, but abandoned by the Soviet government. In spite of that this name has found its way into newspapers outside of Russia, and one meets the Lenin Land, for example, in articles dealing with the recent Arctic travel of the "Italia" under General Nobile. Nicholas II Land and Lenin Land have been used as synonyms in No. 377C Sheet I of the *Daily Science News Bulletin*, issued by Science Service. However, this article, in its essential, is a translation of a German article which is, therefore, responsible for the use of the name of Lenin Land.

The writer will not go into consideration of the question as to how it would be permissible or at least reasonable, only on account of political reasons, to make the change of geographic names which have once appeared on maps. The Franz Joseph Land, for example, still keeps its imperial name, although Austria has become a republic. German geographers mostly

¹"Arctic Pilot," Vol. I, third edition, 1918, p. 510. Compare also the English Admiralty chart No. 55, published in 1916.

still use the names of the Emperor Nicholas II Land and Tsarevich Alexei Island,² introduced by the hydrographic expedition in 1913.

Every change of geographic names must be authorized in some way, and their indiscriminate introduction should never happen. Therefore, there is no reason to introduce the name of Lenin Land against the decision of the most ardent admirers of the late Russian dictator.

I. TOLMACHOFF

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LESSONS FROM THE ST. FRANCIS DAM

THE disaster caused by failure of the St. Francis Dam, near Los Angeles, California, on March 12 and 13 of this year, will long be remembered. Within a brief interval of time hundreds of lives were lost, a fertile valley was reduced to a scene of desolation, and property valued at many millions of dollars was destroyed. The general attention aroused throughout the country was due not merely to the magnitude of the disaster, but also to its unusual character. There have been few failures of large dams; and the collapse of the St. Francis structure, which was new and built of massive concrete, astonished engineers and laymen alike.

With commendable promptness, the governor of California appointed an impartial and able commission to investigate the causes of the failure. With commendable good sense he recognized the place of geology in the investigation and appointed two geologists to serve with four engineers. This commission made a thorough study of the problem in all its aspects, and a printed report was issued recently.¹ The report is a brief, straightforward statement of facts and conclusions. It merits careful study by every civil engineer, every geologist and every one who is interested in the relation of large structural projects to the public safety.

The most significant conclusion of the commission is contained in one direct, unqualified sentence: "The failure of St. Francis Dam was due to defective foundations." So far as the evidence can show, the dam itself was perfectly sound both in design and in construction; but it goes without saying that the best dam in the world, if erected on a weak and leaky base, is a public menace. The degree of defectiveness in the foundations of the St. Francis structure is made

clear by the report. Mica schist, a rock made up of thin, weak layers or folia, is the bedrock beneath the bottom and one side of the valley at the dam site. Conglomerate, composed of poorly cemented gravel and other detritus, underlies the other valley wall. Thus the bedrock is inherently weak under the entire dam; but to make matters much worse, the conglomerate and schist are separated by a wide zone of shearing, in which the rocks have been ground and mashed by powerful earth-forces. When a sample of material from this zone is placed in water it disintegrates rapidly to incoherent particles. Yet this mass of material lay directly under the dam, subject to the softening action and to the enormous pressure of water in the reservoir. It appears, then, that the foundation of the dam had many elements of weakness and none of strength.

The geologic conditions in the valley, including the existence of the shear zone or *fault*, were well known to geologists before the dam was built. No competent geologist would have approved the dam site without serious reservation, and probably very few would have consented to construction of the dam in that place under any consideration. But it does not appear that any geologist had a hand in selecting the site, or in making inspection of the work as it progressed. Why not? The same geologists who took part in the "post mortem," as well as numerous others who knew the local geology, could have been consulted in the beginning. Their knowledge, had it been used at the proper time, would have prevented the catastrophe.

It is easy to point out errors after the damage is done; and not infrequently certain individuals or organizations receive an unjust share of blame for which a common condition or system is responsible. This article is not written with the purpose of censuring any person or any institution. It is intended rather as a protest against a situation that exists in many states, both east and west. There seems to be a tacit assumption in many quarters that the ordinary training of the construction engineer fits him to solve all geological problems he may encounter in his work. It is no reflection on engineers, individually or collectively, to state that this assumption is fallacious. Geology is a complex subject. Many of its problems tax all the resources of men who have devoted the best years of their lives to its study. Without question most engineers charged with the building of dams and other large structures would welcome cooperation by competent geologic specialists.

Disasters always call forth some condemnation of the *status quo* and many suggestions for improvement. In discussions stimulated by the breaking of St. Francis Dam the claim has been made that a special

² New map of the Arctic Region in Pet. Mitt., Erhänz. Heft 191. Also Stiller's Hand-Atlas, Zehnte Auflage.

¹ Report of the commission appointed by Governor C. C. Young to investigate the causes leading to the failure of the St. Francis Dam near Saugus, California; Calif. State Printing Office, Sacramento, 1928.

study of geology should be required of all civil engineering students. Certainly a course in the fundamental principles of geology, emphasizing the applications to engineering practice, should have an important place in the training of construction engineers. Many schools include such a course in their curricula. It cannot be expected, however, that the student will become proficient as an engineer and as a geologist at the same time. He should of course have some basis for appreciating the nature of geologic problems that may confront him in his work. Such an appreciation will serve to emphasize in his mind the need for cooperation with highly trained geologists.

Governor Young's commission stresses the desirability of having all such structures as the St. Francis Dam "erected and maintained under the supervision and control of state authorities." Surely the people of California ought to demand no less than this, because "while the benefits accrue to the builders of such projects, the failures bring disaster to others who have no control over the design, construction and maintenance of such works." Unquestionably state supervision decreases the danger; but in the writer's opinion a further step is desirable—the participation of geologists in the selection and final approval of dam sites should be specifically provided. Certain states require official inspection of such sites, but commonly the board is made up of engineers only. If the system of state supervision were universal, and if each board of engineers for inspection and approval of dam sites included at least one competent geologist, the danger of disastrous failures would be in large part removed.

High dams for water supply and for power projects are essential for present and future development; and doubtless the number of such structures will increase rapidly, especially in certain parts of the West. The recent experience in California furnishes a plain warning that geological conditions at dam sites cannot be ignored. There is reason to believe that California will profit from the lesson. It is the duty of other states also to take any measures that promise to prevent similar disasters within their borders.

CHESTER R. LONGWELL

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ISONTIC?

ONE of the useful premises of science is that between two points equal in some respect there does not tend to be change in that respect. Thus lines or surfaces connecting points that are equal in some respect play a great rôle and we have a number of names applied to particular varieties such as contours for lines

of equal elevation, levels, niveaux. Particularly common are words beginning with "iso"—such as:

isotherm, line connecting points of equal temperature;
isobar, line connecting points under equal atmospheric pressure;
isogam, surface or line of equal gravitative attraction;
isochlor, line connecting points where the water (?) has equal chlorin, etc., etc.

Now I think I need, and it might be useful to others, a word to apply to any line or surface drawn through points equal in some respect, and upon due application to my dictionary and my colleague, Professor Wyatt, I think *isontic* (being equal or equal in being) is about the word I want.

What do others think? One could then speak of a gravitation isontic, meaning thereby the curve connecting all the points where the force of gravitation had the same value, or a sodium isontic in the ocean, connecting point where the seawater had the same per cent. of sodium, of an evaporation isontic or a radium isontic, and if it came into general use be understood, and one would not have to use a long phrase or some queer hybrid or have to hunt up some Greek equivalent which might not be familiar. Is there some word already that will meet my need?

ALFRED C. LANE

TUFTS COLLEGE

A NOTE ON ASTASIA CAPTIVE BEAUCH.

IN rich cultures of *Stentor coerulens* and of *Spirostomum ambiguum*, which were being used for micrurgical studies, I noticed recently a small euglenoid form living with these ciliates, either as a commensal or an endoparasite. They were actively crawling about in the cortical layer of the ectoplasm, just below the pellicle. Their course seemed, on careful focussing, to be restricted to this region.

The shape of the cells was fusiform, the anterior and posterior ends were rounded, and the paramylum granules were in the form of elongated rods. The animals exhibited a high degree of metaboly, during which both anterior and posterior ends retained their rounded form. Accurate cell measurements could not be made on account of the constant metabolic movement, but the length of the cell did not exceed 40 μ when fully extended. No flagellum was seen, nor was a stigma visible.

On the basis of these characters, the form has been identified as *Astasia captiva* Beauchamp, previously reported as an endoparasite in the *Rhabdocoele*, *Catemula lemnae*, in France.

RUTH B. HOWLAND

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THE EUROPEAN RED MITE

DURING the past two or three years, the European red mite has gradually been worming its way into Massachusetts until now it is here in sufficient numbers to become a major pest this summer. Although orchardists have seen examples of its treacherous work during the past season or two, they have just begun to realize the seriousness of this invasion and are taking steps to combat this foe which threatens to become the most insidious of all those pests with which fruit-growers have to contend.

At present in its dormant state, the mite will hatch in two or three weeks, and enter immediately in an attack upon the apple trees, discoloring the foliage, hindering the development of the fruit and in many cases impairing the setting of buds for the 1929 fruit crop. It does its work without being much in evidence, the first sign of its presence being the bronzing of the leaves. The tree, under its attack, begins to wither, the apples develop slowly, fail to reach their natural size and take on no colors; and are consequently sold in the market at unprofitable prices.

According to reports, there is probably no orchard in the state that is not infested with the mite; and as very little is known about it, it is difficult to determine what measures should be employed to control it, although it has been found by recent experiments that a certain oil mixture applied to the eggs will prevent about 95 per cent. of them from hatching. It is evident, however, that more must be known about the mite and its different stages to combat it successfully so that danger from it may be anticipated and prevented.

BIRGER R. HEADSTROM

MEDFORD HILLSIDE,
MASSACHUSETTS

"THE ABILITIES OF MAN"

MAY I add a few lines to the able, original and instructive review of my book, "The Abilities of Man," by Professor Edwin B. Wilson (SCIENCE, March 2, 1928). He points out truly enough that the solution of the "general factor" in ability is obtained by setting—

$$g_x = r_{ag} \cdot m_{ax}, \quad (1)$$

which is only a regression equation and, as such, leaves scope for different true values of g_x ; a scope, in fact, whose extent is measured by the usual $(1 - r_{ag}^2)^{1/2}$. Thus viewed, g_x can hardly be said to be "measured" in anything like the degree that a physicist would demand.

But all this is just my point. I am protesting against the common so-called measurements of "general intelligence" which, when cleared of misconcep-

tions, reduce in fact to equation (1) with an r_{ag} only about .80; often, far less. My plea is that r_{ag} ought to be raised to nearly unity; indeed, for most purposes, it ought to be not less than .99. Whereupon, (1) approximates to an ordinary equation, and does give a measurement in the same general sense at any rate that readings from a thermometer measure temperature.

As regards Professor Wilson's suggestions arising from the transformation of correlations, I hope to say something about this later on. At present, his development of the topic seems to me full of interest and of future, but I still find some difficulties in it. In particular, I am troubled about his making all the correlations between the transformed variables equal to zero, and would like to know how far he regards this as essential to his standpoint.

C. SPEARMAN

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A McLEOD GAUGE OF WIDE RANGE

ONE disadvantage of the ordinary form of the McLeod gauge is that the range of pressures it is capable of indicating is too small for many purposes. From Boyle's law the pressure measured by the gauge is given by

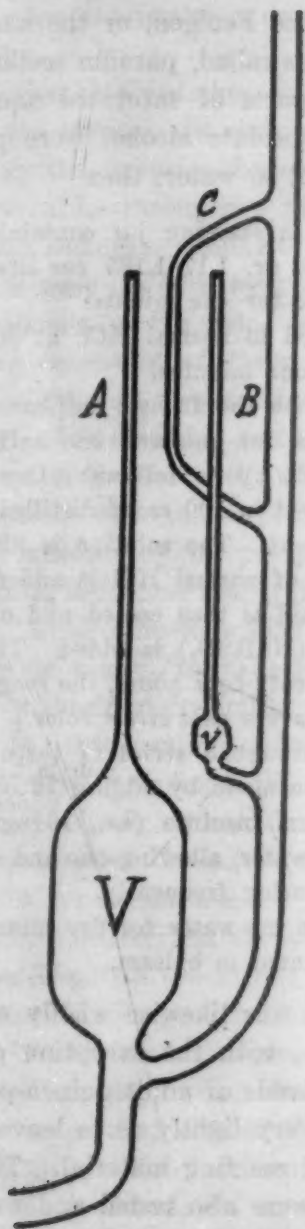
$$P = h^2 a / V \quad (1)$$

where V is the volume of the air in the bulb forced by mercury into the capillary of area a to occupy a space of h cms against a pressure of h cms of mercury. It is evident from the formula that h is the only factor that is varying with the pressure of the gas in the apparatus. This factor, the length of the capillary, can not be made much larger than 20 cms without making the gauge very cumbersome. The smallest reliable reading of the height of the mercury column is about 1 mm. A capillary 20 cms long is capable of indicating pressures up to 4×10^4 times this reading. In an instrument capable of indicating a vacuum of 10^{-6} mms the highest measurable pressure would be 4×10^{-2} mms, which is too small for many purposes.

Attempts have been made to overcome this defect by varying the second factor of the right-hand side of equation (1), the area of the capillary sealed to the reservoir V .¹ This is done by sealing on to the reservoir several tubes of different sizes one on top of the other instead of a single capillary. In this manner the range could be extended to any desired value. A gauge like this is, however, difficult to calibrate be-

¹ See: L. Dunoyer: "Vacuum Practice." (Translated by J. H. Smith.)

cause of the distortions of the capillaries at the junctions. Moreover, elaborate corrections for the difference in the surface tension of mercury in the various tubes must be made before the instrument can be used.



It is much more convenient to extend the range of the gauge by varying the third factor of the right-hand side of equation (1), $-V$, the volume of the reservoir. This can be done by having another vessel and capillary sealed parallel to the main one in the manner shown in the figure. The usefulness of this form of gauge could be greatly increased if a few points be taken into consideration in the design of the apparatus.

In experiments requiring frequent admission of the outside air it is impractical to have the capillary tube smaller than 0.5 mm^2 , as the mercury is liable to stick to the glass unless the gauge is baked out after every run. It is also inconvenient to have the reservoir much larger than 300 cc. With a capillary 20 cms long the range of the gauge would be from

1.66×10^{-6} mms down to 6.6×10^{-2} mms. Now if the volume v of the smaller reservoir be made .01 that of V and a similar capillary tube be sealed on to it the highest and lowest readings on this additional gauge would be 1.66×10^{-4} and 6.6 mms respectively. The addition of a reservoir of three cc extends the range of the gauge down to pressures which can easily be measured with an ordinary mercury manometer.

If the three capillaries A, B and C are of the same diameter no corrections for surface tension need be applied. Moreover, if the capillaries A and B end at the same level and the volume v be .01 that of V the same calibration chart could be used for the combined gauge, the difference for each being only in the decimal point. The volume of the smaller reservoir could be adjusted to the proper capacity by varying the length of the connecting tube. Even if its size is not quite the proper fraction of V the overlapping of the ranges of the separate gauges enables one to determine the proper correction factor by means of the larger gauge.

A. A. BLESS

CORNELL UNIVERSITY.

A FIELD PHOTOMICROGRAPHIC APPARATUS

In the course of investigation of the Sockeye Salmon at Cultus Lake, British Columbia, there was arranged a unique and simple means of photographing small organisms, for example, parasitic copepoda adhering to the host yearling Sockeye. Inasmuch as the apparatus may be readily carried and used in the field and may solve some of the difficulties encountered in recording observations it is herewith described.

The camera used in all cases was an Eastman Graflex, with 4.7 anastigmatic lens. The largest image possible with this lens was much too small to bring out the distinguishing features. To the face of the camera lens was applied an ordinary watchmaker's eyeglass, held in place by a strip of black paper fitted tightly around the front of the camera and attached at the sides with gummed labels. The aperture in the black paper through which the eyeglass projected was made slightly smaller than the circumference of the outer edge of the tube of the eyeglass, so that the flared tube would completely fill the opening. By this means the lens could be brought to within three inches of the object. Excellent photographs were obtained at comparatively short exposure, giving a magnification of approximately five times. In the example above mentioned the parasitic copepods were clearly displayed attached to the gills of the host yearling Sockeye.

R. E. FOERSTER

BIOLOGICAL BOARD OF CANADA

SPECIAL ARTICLES

THE MICROCHEMISTRY OF NUCLEAR INCLUSIONS IN VIRUS DISEASES

THE cellular response in diseases caused by filterable viruses is very pronounced and to the best of our knowledge quite characteristic.¹ Curious "inclusion bodies" are produced in the nucleus, in the cytoplasm or in both. For the cytologist the nuclear ones are particularly interesting because it is distinctly unusual for nuclei to react so profoundly and apparently so specifically in diseased conditions.

The classical studies of Lipschütz and Luger and Lauda published in 1921 relative to the nuclear inclusions in herpes constitute the point of departure for most of the recent work. They gave rise to a controversy which has never been settled. Lipschütz and his followers regard the inclusions as combinations of living virus and nuclear material in which the causative micro-organisms themselves are microscopically visible in the form of extremely minute particles of uniform size; whereas Luger and Lauda look upon them as stages in a non-specific type of degeneration which they style "oxychromatic" because the inclusions are "oxyphile" in the sense that they have a strong affinity for "acid" dyes, such as eosin. Inclusions something like those in herpes had previously been reported in several diseases, of which the following may be mentioned: smallpox, chickenpox, Borna disease of horses, and the salivary gland disease of guinea-pigs. Since 1921 other inclusions have been found in Virus III disease of rabbits and it is probable that still others await discovery.

By most investigators these nuclear inclusions are considered to be pathognomonic of the action of filterable viruses. But knowledge of their wide occurrence in man and animals has developed so rapidly and has been so directly of practical value that the difficult question of their chemical composition has been rather set aside. Because they are colored in the same way by non-specific stains means but little and is not a good reason to assume that they are alike in the different diseased conditions. It is the purpose of this paper to briefly report their reactions to the Bensley-Macallum test for masked iron and the Feulgen reaction, as well as to determine a few of their solubilities.²

¹ T. M. Rivers, "Filterable Viruses," Williams & Wilkins Co., Baltimore, 1928.

² Thanks are due to Dr. T. M. Rivers for tissues from cases of chicken-pox and for Virus III and to Dr. P. K. Olitsky for the virus of herpes and for tissues from a case of Borna disease.

The test for iron gave consistently negative results with the intranuclear inclusions of chicken-pox herpes, Virus III disease of rabbits and the salivary gland disease of guinea-pigs, so we may conclude that they are all alike in so far that they do not contain detectable amounts of iron in organic combination.

In applying the Feulgen, or the nucleal reaction,³ as it is sometimes called, paraffin sections of material fixed in equal parts of saturated aqueous corrosive sublimate and absolute alcohol were passed through xylol and alcohol to water, then

(1) Placed in a staining jar containing normal HCl (82.5 cc HCl, sp. gr. 1.17-1.185 per liter of water) at room temperature for one minute.

(2) Transferred to normal HCl, at 60° C. and there hydrolyzed for four minutes.

(3) Treated with the fuchsin sulphurous acid reagent in a staining jar for one and one half hours. (This reagent was made up as follows: One gram of basic fuchsin is dissolved in 100 cc of distilled water with the aid of a little heat. The solution is filtered while still warm and 20 cc of normal HCl is added to the filtrate. The resulting fluid is then cooled and one gram of dry sodium bisulfite (NaHSO_3) is added. Then, after standing for about twenty-four hours, the reagent is ready for use and should have a pale straw color.)

(4) Passed through a series of three jars, each containing a solution made by adding 10 cc of a molecular solution of sodium bisulfite (i.e., 104 grams per liter), to 200 cc of tap-water, allowing one and one half minutes in each and agitating frequently.

(5) Washed in tap-water for five minutes, dehydrated, cleared and mounted in balsam.

This reaction was likewise wholly negative for the same inclusions, with the exception of those in the submaxillary glands of adult guinea-pigs, which were tinged, but so very lightly as to leave some doubt of the presence of reacting material. The inclusions in Borna disease were also tested and were found to be negative. The available evidence seems to indicate that a positive result is only given by substances containing thymonucleic acid. However this may be, the reaction is specific and elective for a distinctive nuclear component of some kind and has the advantage of being easily applied. It is far more specific than any basic stain which will color in addition to nuclear chromatin the Nissl bodies and the chromidial material of gland cells, substances left entirely untouched by the Feulgen reaction.

All the inclusions studied were found to be remarkably resistant to solvents. They were well preserved in mixtures containing large amounts (80 per cent.) of acetic acid and chloroform and were not noticeably dissolved by 95 per cent. ethyl alcohol.

³ *Enzy. f. Mkr. tech.*, 1927, Bd. III, 1729.

Attempts to secure a clearly positive Millon's reaction were unavailing. Other microchemical studies are in progress and will be reported elsewhere. Among the reactions which should be applied are Macallum's tests for potassium and for chlorides, because these may furnish clues to the nature and source of substances added when the nuclei undergo hypertrophy, as they often do.

From the results obtained thus far, it seems clear that, although the viruses are obviously distinct, the material forming the inclusion bodies appears to be in some respects alike throughout the series of diseases examined. But this similarity should not be taken at all as a measure of a hypothetical and corresponding similarity in the mode of action of the viruses; for the reactivity of the nucleus is so restricted that it might well respond to different stimuli in the same way. The available material for building up the inclusions is limited both in amount and in variety as compared with that existing in the cytoplasm, and the nucleus by its position is sheltered from environmental influences acting upon the periphery of the cell. Such influences may be different in kind, and there is reason to believe that they actually do differ within certain limits, while the transmitted effects to the nucleus may be identical. Consequently, in striving to know the viruses by their deeds, which is about all we can do at present, we must proceed cautiously. It is this that makes the problem largely a cytological one.

The results are, moreover, at variance but not absolutely incompatible with the theory that the inclusions are composed in large part of the causative microorganisms themselves—if indeed the inciting agents are actually living, which has certainly not been proved in the case of any of those mentioned. In the first place, iron, which is known to be of widespread occurrence in detectable amounts in living things, was observed in the nuclear inclusions to be conspicuous by its absence.

Secondly, the material responsible for the Feulgen reaction, which is probably thymonucleic acid, while not quite so ubiquitous is nevertheless an essential constituent of animal cells including the pathogenic protozoa, yet, like iron, it was absent in all the inclusions, with the possible exception of some in the submaxillary glands of old guinea-pigs. The questionable reaction which these gave should not be weighed in the balance one way or the other. They constitute a special case, for, as will be shown in a later communication, the cells tested, though persisting in the living animal, had been dead for days, perhaps for weeks, before the examinations were made.

Further evidence pointing in the same direction has been available for some years, but has not been stressed. It is known that some of the inclusions that we are considering are occasionally feebly basophilic but that the majority throughout their whole history are strongly acidophilic (or oxyphilic). A parallel is not easily found of any existing microorganism which is so consistently acidophilic in its reaction. Even the Rickettsia of Rocky Mountain spotted fever, which approximate most closely to the inclusions, being in a stage of their life history parasitic in masses within nuclei, are distinctly basophilic.

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THE EFFECTS OF X-RAYS IN PRODUCING MUTATIONS IN THE SOMATIC CELLS OF *DROSOPHILA MELANOGASTER*

THE signal success of my colleague, Dr. H. J. Muller, in producing mutations and rearrangements of genes in the germ cells of *Drosophila* by X-radiations, suggested the possibility of securing similar results by this method in somatic cells. It was thought that if the genes in the somatic cells could be changed by the means of X-rays, the facts thus obtained would be of importance, especially in studying the mutation rate and in determining the behavior of specific genes during development.

With this in view, a series of experiments, involving the use of several different genes, has been planned and is now being carried out in this laboratory. For the first set of experiments, the sex-linked genes for eye color were selected as suitable characters for study. The compound eye of insects is especially well adapted to this kind of work. It is composed of a series of definite units, the ommatidia, in which any change of color of one or more of the units can be detected. In this paper we shall report the results obtained from raying the F_1 eggs and larvae of crosses between the normal red-eyed fly and the white-eyed mutants.

The relatively low frequency with which mutations occur, in the individual genes, even after X-ray treatment, makes remote the chance that two identical dominant genes in the same somatic cell would be changed at the same time. The object of making the cross is, therefore, to obtain females heterozygous for the sex-linked genes. Since the male has but a single X-chromosome, his somatic cells will have either the dominant or recessive gene, but not both.

The cultures to be rayed were made up in a manner such that the difference in age between the youngest and oldest eggs or larvae in any given culture would not exceed twelve hours. These cultures were

then kept in an incubator, run at 27° C. until the time for raying, and after treatment were allowed to develop at room temperature. The control cultures were handled in the same manner, except that the X-ray treatment was omitted.

The raying has been done on the standard Victor machine, equipped with a broad-focus Coolidge tube with tungsten target. The machine was operated at 50 kv., 5 ma, at a target distance of 12 cm. An aluminum filter 1 mm. thick was interposed between the tube and the culture. Several different lengths of treatment were given the different cultures, which varied in age from the egg stage to fully formed pupae. As a matter of convenience, the difference in dosages was made at five-minute intervals, and designated as D-1 for the five-minute or shortest treatment, D-2 for the ten-minute, and on up to D-10, or 50-minute dose, which was the longest treatment given.

Four different sets of experiments have been performed. The first set was necessarily of a preliminary character and consisted in treating cultures of larvae in different stages of development. The doses used were D-1, D-2, D-3 and D-5 (only three small cultures). The cultures contained the F_1 larvae of the cross between normal or wild females and yellow-white males. The results obtained were largely negative—only two flies showed any effects of the X-rays, and none was found with white ommatidia. It was evident that the lighter dosages were not sufficient to bring about much change. Consequently, in all the succeeding experiments, the longer treatments were given. I have since used almost exclusively the D-5 and D-10 doses.

In the second set of experiments the same cross was made as used in the preceding set. In all twenty-three different cultures were given the treatment, twelve the D-5 dose and eleven the D-10. These twenty-three cultures covered the entire range of development, from freshly laid eggs to fully formed pupae. From the eggs and larvae of the D-5 treatment 760 flies developed, 382 females and 378 males. White ommatidia were not found on the eyes of the males, but sixteen females had such ommatidia. These were found either singly or in groups of two or more. The numbers of white ommatidia in the sixteen females were as follows: 1, 1, 2, 2, 3, 3, 4, 5, 5, 6, 7, 12, 14, 24, 133 and 239, respectively. The D-10 treatment yielded 208 females and 180 males. Eleven females and three males had white ommatidia. The numbers were as follows: Females, 1, 2, 2, 2, 2, 3, 3, 4, 5, 9, 27; males, 2, 5, 13. In each of three cases the eyes of females had white ommatidia at two different locations, making a total for the D-10 series of seventeen different areas that had undergone the change from red to white.

In the third set of experiments, normal gray-red females were crossed to gray-white males and the F_1 larvae rayed as before. Only six cultures were treated, five at D-5 and one at D-10. These gave seventy-six females and sixty-six males. Two females showed white ommatidia; one with two groups on the right eye of ten and three, respectively, the other with a group of twenty on the left eye and a group of four on the right eye.

In the fourth set of experiments the larvae of normal flies were treated at various stages with D-5 and D-10 doses. The treated cultures gave 103 females and 98 males for the D-5 series, and 114 females and 89 males for the D-10 series. White ommatidia were not present on the eyes of the 217 females, but two males from the D-5 and three males from the D-10 series had white ommatidia, with the following numbers: 1, 2, and 1, 2, 3, respectively.

To summarize the data for the D-5 and D-10 series: the 217 females from treated larvae and homozygous for the sex-linked genes showed no change in eye color; the 666 females from treated larvae, and heterozygous for this gene, showed thirty-four separate white areas (either single or groups of white ommatidia); the 807 males from both series gave eight males showing white areas.

The various controls for the different sets of experiments gave 1,798 flies, of which 991 were females and 807 males. The eyes of all these flies were carefully examined for the presence of white ommatidia, but none was found. It is certain, therefore, that the appearance of such ommatidia in flies coming from treated eggs or larvae is due to the effects of X-radiations.

Three possible suggestions may be made as to the nature of the effect of X-rays in producing white ommatidia. One is that the effect is non-genetic, that is, it does not involve a change in the gene or chromosome. If this is correct, then the eyes of females, homozygous for the sex-linked gene for eye color, should show white ommatidia after the treatment, but this is found not to occur. A second suggestion is that the change is brought about by a gene mutation, the so-called point mutation. All eight cases found among males can be explained on this basis, and also a proportional number of cases among the heterozygous females. Since about one in every hundred males from treated larvae (eight in 807) shows the mutation, then there should be six or seven similar mutations among the 666 females, but there were thirty-four cases of white ommatidial areas present among these females. How are we to explain the appearance of this excess of cases? The best interpretation is that they are the result of chromosomal abnormalities, involving the loss of the X-chromosome,

at least that part of it that carries the dominant gene. Muller has found cases of this character in flies derived from treated germ cells.

This interpretation will enable us to understand why it is that white ommatidial areas appear more frequently among heterozygous females than among males. If the dominant gene is lost through chromosomal elimination at any cell-division in the somatic cells of the female, the descendant-cells will show the effects of the recessive gene, in this case white ommatidia. In homozygous females the loss, by chromosomal elimination, of one of the dominant genes would not be detected, because of the presence of a dominant gene in the other X-chromosome. Finally, in males the chromosomal elimination of the dominant gene of the single X-chromosome would result in the death of the cell, and hence white ommatidia would not appear.

The limited scope of this note does not permit a report on many other interesting facts that have come out in the work. However, I shall mention briefly three facts that are of more than general interest. The first has reference to the age of the larvae at which X-radiations produce white ommatidia. Briefly stated, the general rule is as follows: If eggs or very young larvae (ten to twenty-two hours old) are treated, the resulting white areas will be large (*e.g.*, the two cases of 133 and 239 ommatidia); if raying is done at twenty-four to forty-eight hours of age, the white areas will have from three to fifteen ommatidia; if the treatment is given during the late larval stage, there is formed, usually, a single white ommatidium; finally, raying pupae stages failed to produce white ommatidia. This means that if a mutation occurs during the early stages of development, when there are yet but few cellular elements present in the eye rudiment, the white area will be amplified by cell divisions of the affected cell. If mutations are induced at successively later stages, there will be, in each instance, fewer cell-descendants, and, consequently, a series of white areas of decreasing size will be produced.

The second point of importance has reference to the production of gene mutation in the germ cells of the rayed larvae. From the cross between normal grayed females to yellow-white males, forty-four males and twenty-nine females developed from rayed larvae were tested out for gene mutations. Thirteen females from the controls were also tested. Twelve of these were fertile and gave 1,732 offspring, among which no visible mutation was found. Fourteen of the twenty-nine females from treated larvae were fertile and gave 1,861 offspring, of which five showed visible mutations. Twenty-three of the forty-four tested males were fertile, and gave 944 male offspring, of

which twenty showed visible mutations. There were four cases in which two or more flies showed the same visible mutation. This is due to the fact that an early germ cell divided two or more times after the mutation took place. Some of the mutations obtained are new, others, such as "white" and "garnet-like," are like those previously known. Several of these have been further tested and found to breed true and do not produce "mosaics."

The final point of general interest has reference to the effects of X-radiation on somatic characters other than that of eye color. Nearly every treated culture yielded flies showing somatic modifications. Some of these very closely resemble certain of the normal mutations previously described (*e.g.*, "star" and "notch"). However, these induced somatic modifications differ from those of the normal mutants in two important respects; first, they are usually asymmetrical, and second, genetic tests show that they are never inherited.

Throughout this study I have had the advantage of free access to Dr. Muller's extensive stocks of *Drosophila*; for this and many other courtesies, I am indebted to him.

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SOCIETIES AND ACADEMIES

THE AMERICAN ASSOCIATION OF MUSEUMS

THE twenty-third annual meeting of the American Association of Museums was held in Washington, D. C., from May 23 to 25. A feature of the conference was the opportunity which it afforded for wide contacts through the fact that the American Federation of Arts held its meeting at the same time, and the Association of Art Museum Directors met on the two preceding days in the same city.

The past year—the fifth since the establishment of the association in its headquarters at Washington—has witnessed work which looks farther into the future than that of any previous twelve months, according to the report of the director of the association rendered at the opening session of the meeting on May 16. Development of international relations, rapid extension of outdoor educational work and publication of books and reports were cited among other achievements.

The following excerpts from the report indicate the character of the year's activity.

The director spent part of the winter in Europe on two missions. First, by invitation, he visited the International Office of Museums at Paris and helped to develop a basis of cooperation between national and re-

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gional groups throughout the world. He then went to London to confer, by request, with the British Royal Commission on Museums concerning general museum matters in the United Kingdom. While abroad, he visited 115 museums in six countries, and established immediate contact with five museums associations.

Another branch of international work promises to develop as a result of a grant of \$3,000 made by the Carnegie Foundation for International Peace. The Association's Committee on Pan-American Cooperation has the use of this fund and is maturing plans.

On the closing day of the Washington meeting further reference was made to this project. It was announced that following the committee's recommendation, Director Coleman had been authorized to visit the museums of Latin-American countries during the summer of 1928. The report continues: .

The Committee on Outdoor Education, under the active leadership of Dr. Hermon C. Bumpus, has completed a trailside museum building at Bear Mountain, Palisades Interstate Park, and has been privileged to see the work of installing equipment and exhibits go forward under a cooperative arrangement between the Park administration and The American Museum of Natural History. The Committee has also nearly finished a trailside museum building in the Grand Canyon National Park.

During the year Dr. Bumpus visited the previously constructed museum in Yosemite Valley to observe it in operation. These three projects have been financed by substantial grants from The Laura Spelman Rockefeller Memorial.

Quite recently the Memorial made two new grants to the Association for extension of its work in national parks. A sum of \$118,000 was appropriated as follows: \$112,000 for building, equipping and furnishing museums and trailside museums in Yellowstone National Park, and \$6,000 for expenses of the Committee. Also a sum of \$10,000 was granted through the Association for the expenses of a new committee, to be appointed by the Secretary of the Interior, to make a survey of educational work in national parks and monuments.

Coleman's "Manual for Small Museums," of which a few advance copies appeared early in 1928, was released by the publisher in September. Reports of its use in founding new museums are heard from Russia, Japan and India.

Further efforts on behalf of small museums have been made under a grant of \$5,000 from the Carnegie Corporation carried over from last year, and this work will be continued under the balance of the fund which still remains.

"Industrial Art and the Museum," a report by Professor Charles R. Richards on studies made in Europe, has appeared as a bound volume and has had wide circulation.

Professor Edward R. Robinson, of Yale University, has completed the first phase of a psychological study of

museum visitors, and the report has been issued as Number 5 of the Association's new series of publications. This represents the first results of a scientific scrutiny of factors which have not previously been investigated.

Assistant Secretary Smith has completed the compilation of a three-hundred page volume to be known as "A Bibliography of Museums and Museum Work," which will be off the press July 1.

At the request of the National Conference on Outdoor Recreation, the director has prepared a report on "Contributions of Museums to Outdoor Recreation" which has just been published by the conference.

The report speaks of the two serial publications—*The Museum News* and the *New Series* of monographic papers—and of the information service of the Washington office. During the year the last has entailed preparation of service reports of greater or less length. Work of three regional conferences is cited, and the statement closes with a summary of the treasurer's report and the financial outlook as follows:

The Laura Spelman Rockefeller Memorial has continued its annual subsidy of one dollar for each two dollars produced by memberships and contributions. The Association is indebted also to the museums which hold membership, since all but a few of them have now complied with the request that their dues be determined by their budgets on the basis of one dollar of dues for each thousand dollars of their expenditure for operations.

The report of the treasurer reflects, in the general fund, a current surplus of \$3,608.22, which brings the total of surplus to \$25,894.95. There have been seven special funds, of which six show balances and one is now closed out.

Assured income—namely, that from memberships, sales and interest—promises soon to stand at a total of \$10,000 a year. The Association requires at least \$10,000 more in order to work with any effectiveness. This balance has been met in past by contributions and the Memorial's grant, but soon it should be capitalized. To hope for annual subsidy indefinitely is futile, and further to be continually under the necessity of soliciting gifts is subversive of usefulness. Endowment to the extent of a quarter million dollars must be secured. Twice that amount would put the Association in a position of strength without inflating it.

Fortunately, there is every reason to hope that the need will be met. This opportunity for benefaction seems too clear to be long overlooked. Its significance is indicated by the fact that it stands ready to bestow upon some patron a permanent and commanding place in the history of public service and in the annals of cultural development.

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Director

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